First set. Indoors. Average of eleven days.

	°F.
Temperature of room	76.5
Temperature between coat and vest	84.9
Temperature between vest and linen shirt	87.4
Temperature between linen shirt and woolen undershirt	90.3
Temperature between woolen undershirt and skin	95.5
Temperature under the tongue (average of six days)	98.5

Second set. Outdoors ten minutes. Average of eleven days.

Atmospheric temperature	39.3
Temperature between coat and vest	65.3
Temperature between vest and linen shirt	74.6
Temperature between linen shirt and woolen undershirt	81.3
Temperature between woolen undershirt and skin	93.8
Temperature under the tongue (average of six days)	98.3

Third set. Outdoors twenty minutes. Average of eleven days.

Atmospheric temperature	39.3
Temperature between coat and vest	61.1
Temperature between vest and linen shirt	69.7
Temperature between linen shirt and woolen undershirt	78.1
Temperature between woolen undershirt and skin	92.6
Temperature under the tongue (average of six days)	98.0

Fourth set. Ten minutes after returning indoors. Average of eleven days.

Temperature of room	75.7
Temperature between coat and vest	77.9
Temperature between vest and linen shirt	80.8
Temperature between linen shirt and woolen undershirt	86.3
Temperature between woolen undershirt and skin	93.1
Temperature under tongue (average of six days)	98.0

Average of 2 p. m. meteorological observations for eleven days.

Temperature of air	39.3
Temperature of wet-bulb thermometer	36.0
Relative humidity	73.0
Absolute humidity (grains per cubic foot)	2.08
Velocity of wind (miles per hour)	8.3

From the limited character of these observations it is not expected that the values derived from them will have other than a very restricted application. The chief reason for publishing them in their present shape is that the field of inquiry suggested by them is an extensive one and should yield to more complete investigation many facts of great practical utility; and, furthermore, because with the exception of some similar observations quoted by Van Bebber as having been made by Rubner they are the only ones of the kind known to the writer.

The following values are given by Van Bebber (Hygienische Meteorologie, W. J. Van Bebber, 1895, p. 132):

	Atmospheric temperature.	
	50° F.	79° F.
Temperature between coat and vest	73.6	83.8
Temperature between vest and linen shirt	75.9	84.7
Temperature between linen shirt and woolen shirt	77.4	85.3
Temperature between woolen shirt and skin	90.9	89.9

The statement of the atmospheric temperature is the only information given relative to the meteorological conditions under which these values were obtained.

At the present time it would evidently be imprudent, with the scanty data available, to dogmatize as to the relative importance of either the different meteorological elements or the various parts and qualities of clothing, but the following points appear noticeable enough to mention: The temperature of the different layers of clothing was influenced decidedly by the prevailing temperature of the immediate surroundings, the former rising and falling with rises and falls in the latter, but the degree of change was variable, and perhaps, if not certainly, was very much affected by the velocity of the wind. There was one point wherein a result of the writer's experiments differed from a corresponding one as given by Van Bebber, i. e., that the lower the atmospheric temperature the lower also was the temperature between the woolen shirt and the skin, this was contrary to Rubner's experience, and is worth calling attention to, inasmuch as Rubner appears to have attached much significance to the increased temperature between the skin and undershirt at the lower atmospheric temperature.

Another point noticed was in connection with the temperature of the body as shown by that taken in the mouth. Upon going outdoors the body temperature always fell, and the fall was greater in proportion to the time of exposure. Furthermore, upon returning indoors it did not rise quickly, but ten minutes afterwards remained as low as the last observation outdoors. Although no systematic observations were made with reference to ascertaining the time required for the body to regain its original degree, yet in the few casual experiments that were made it took from twenty to thirty minutes.

Coincident with the thermometric observations an attempt was made to estimate the subjective sensations while outdoors with reference to cold and warmth, and to express them in a few words ordinarily used. The degree of success or failure is shown in the column headed "subjective sensation" in the table appended.

THE STANDARD SYSTEM OF COORDINATE AXES FOR MAGNETIC AND METEOROLOGICAL OBSERVATIONS AND COMPUTATIONS.

By Prof. FRANK H. BIGELOW, dated June 22, 1897.

Uniformity of method in observation and also in computation constitutes one of the canons of modern science. As matters now stand, the comparative study of the published results of the observations in terrestrial magnetism and meteorology discloses an annoying variation in units and coordinate systems; a similar conflict prevails throughout the papers devoted to an analytic discussion of the observations. Since final general deductions can be best secured for science by cooperation, based upon uniform standards of coordinates, notation, and fundamental constants, it is the first duty of investigators to come to a sound agreement regarding these standard systems. In order to exhibit the present status, especially in the writings of the authorities who have chiefly influenced the development of these subjects, the coordinate axes and directions employed by them have been collected in tables for inspection. The papers cited are as follows:

1. *Gauss.*—General Theory of Terrestrial Magnetism, Taylor's Translations. 1839.
2. *Erman* and *Petersen.*—Erscheinungen des Erdmagnetismus. 1874.
3. *Maxwell.*—Electricity and Magnetism. 1881.
4. *Mascart* and *Joubert.*—Electricity and Magnetism, Atkinson's Trans. 1883.
5. *Schuster.*—Diurnal Variation of Terrestrial Magnetism. 1889.
6. *Schmidt.*—Entwickelung der allgemeinen Formeln, etc., Deutsche Seewarte. 1889.
7. *Schmidt.*—Neue Berechnung des Erdmagnetischen Potentials. 1895.
8. *Von Bezold.*—Uber Isanomalen des Erdmagnetischen Potentials. 1895.
9. *Von Bezold.*—Zur Theorie des Erdmagnetismus. 1897.
10. *Carlheim-Gyllensköld.*—L'attraction magnetique de la terre. 1896.
11. *Laplace.*—Mécanique Céleste. Bowditch Trans. 1829.
12. *Ferrel.*—Professional Papers. S.O. VIII. Waldo. 1882.
13. *Ferrel.*—Meteorological Researches. U. S. C. & G. S. Report. 1877.
14. *Ferrel.*—Recent Advances in Meteorology. S.O. 1885.
15. *Oberbeck* and *Margules.* Abbe's Translations. 1891.
16. *Sprung.*—Meteorologie. 1885.

17. *Thomson* and *Tait*, *Helmholtz*, *Heaviside*, *Hertz*, *Poincaré*, *Boltzmann*, *Watson* and *Burbury*, *Basset*, in their respective treatises.

In order to bring the notations actually used by these authors into a single scheme for comparison, the following notation is now adopted: R, radius of earth; r, any distance from the center of the earth; θ, north polar distance; φ, north latitude; λ, east longitude. The first column of the

TABLE 1.—*The coordinate systems used in terrestrial magnetism.*

Author.	Potential.	Coordinate forces.	Direction.	Original notation.	
Gauss (1839), pp. 200, 202, 204	$V=-\Sigma\frac{m}{r}$.	$X=+\frac{dV}{dx}=-\frac{dV}{rd\theta}$.	North.	$u=\theta$	$X=-\frac{dV}{R\,du}$.
		$Y=+\frac{dV}{dy}=-\frac{dV}{r\sin\theta\,.\,d\lambda}$.	West.	$R=r$	$Y=-\frac{dV}{R\sin u\,d\lambda}$.
		$Z=+\frac{dV}{dz}=-\frac{dV}{dr}$.	Nadir.		$Z=-\frac{dV}{dr}$.
Erman and Petersen (1874), pp. 26, 30	$V=-\Sigma\frac{m}{r}$.	$X=+\frac{dV}{dx}=-\frac{dV}{rd\theta}$.	North.	$u=\theta$	$X=-\frac{dV}{r\,du}$.
		$Y=+\frac{dV}{dy}=-\frac{dV}{r\sin\theta\,.\,d\lambda}$.	West.		$Y=-\frac{dV}{r\sin u\,d\lambda}$.
		$Z=+\frac{dV}{dz}=-\frac{dV}{dr}$.	Nadir.		$Z=-\frac{dV}{dr}$.
Maxwell (1881), II, p. 121	$V=+\Sigma\frac{m}{r}$.	$X=-\frac{dV}{dx}=+\frac{dV}{rd\theta}$.	North.	$l=\phi$	$X=-\frac{dV}{adl}$.
		$Y=-\frac{dV}{dy}=+\frac{dV}{r\sin\theta\,.\,d\lambda}$.	West.	$a=R$	$Y=-\frac{dV}{a\cos l\,.\,d\lambda}$.
		$Z=-\frac{dV}{dz}=-\frac{dV}{dr}$.	Zenith.		$Z=-\frac{dV}{dr}$.
Mascart and Joubert (1883), p. 413	$V=+\Sigma\frac{m}{r}$.	$X=-\frac{dV}{dx}=+\frac{dV}{rd\theta}$.	North.	$u=\theta$	$X=+\frac{dV}{r\,du}$.
		$Y=-\frac{dV}{dy}=+\frac{dV}{r\sin\theta\,.\,d\lambda}$.	West.	$l=\lambda$	$Y=+\frac{dV}{r\sin u\,dl}$.
		$Z=-\frac{dV}{dz}=-\frac{dV}{dr}$.	Zenith.		$Z=-\frac{dV}{dr}$.
Schuster (1889), p. 475	$V=+\Sigma\frac{m}{r}$.	$X=-\frac{dV}{dx}=+\frac{dV}{rd\theta}$.	North.	$u=\theta$	$X=+\frac{dV}{adu}$.
		$Y=-\frac{dV}{dy}=+\frac{dV}{r\sin\theta\,.\,d\lambda}$.	West.	$a=R$	$Y=+\frac{dV}{a\sin u\,d\lambda}$.
		$Z=-\frac{dV}{dz}=-\frac{dV}{dr}$.	Zenith.		$Z=-\frac{dV}{dr}$.
Schmidt (1889), p. 7; (1895) p. 9	$V=+\Sigma\frac{m}{r}$.	$X=-\frac{dV}{dx}=+\frac{dV}{rd\theta}$.	North.	$u=\theta$	$X=+\frac{dV}{r_0\,du}$.
		$Y=-\frac{dV}{dy}=-\frac{dV}{r\sin\theta\,.\,d\lambda}$.	East.	$r_0=r$	$Y=-\frac{dV}{r_0\sin u\,d\lambda}$.
		$Z=-\frac{dV}{dz}=+\frac{dV}{dr}$.	Nadir.		$Z=+\frac{dV}{dr}$.
Von Bezold (1895), p. 3	$V=-\Sigma\frac{m}{r}$.	$X=+\frac{dV}{dx}=-\frac{dV}{rd\theta}$.	North.	$\beta=\phi$	$X=+\frac{dV}{r\,d\beta}$.
		$Y=+\frac{dV}{dy}=+\frac{dV}{r\sin\theta\,.\,d\lambda}$.	East.		$Y=+\frac{dV}{r\cos\beta\,.\,d\lambda}$.
		$Z=+\frac{dV}{dz}=-\frac{dV}{dr}$.	Nadir.		$Z=-\frac{dV}{dr}$.
Carlheim-Gyllensköld (1896), p. 4	$V=-\Sigma\frac{m}{r}$.	$X=+\frac{dV}{dx}=-\frac{dV}{rd\theta}$.	North.	$\mu=\cos\theta$	$X=+\sqrt{1-\mu^2}\,.\,\frac{dV}{r\,d\mu}$.
		$Y=+\frac{dV}{dy}=-\frac{dV}{r\sin\theta\,.\,d\lambda}$.	West.	$\omega=\lambda$	$Y=-\frac{dV}{r\sqrt{1-\mu^2}\,.\,d\omega}$
		$Z=+\frac{dV}{dz}=-\frac{dV}{dr}$.	Nadir.		$Z=-\frac{dV}{dr}$.

Green, Mathematical Papers (1828), p. 21, adopts the positive potential function $V=+\Sigma\frac{m}{r}$.

table contains the author and reference page, the second, the author's definition of the potential, the third, his coordinate forces when expressed in the standard notation adopted above, the fourth, the positive coordinate directions, and the fifth the original notation as employed in the respective papers, together with the equivalents in the standard system.

It is thus seen that in terrestrial magnetism Gauss, Erman and Petersen, Von Bezold, and Carlheim-Gyllensköld adopt the definition of the potential function $V = -\Sigma\frac{m}{r}$, where m is the elementary mass and r the distance; but that Maxwell, Mascart and Joubert, Schuster, and Schmidt adopt the form $V = +\Sigma\frac{m}{r}$. This radical divergence, therefore, separates all the writings on magnetism into two groups. It is also seen that Gauss, Erman and Petersen, and Carlheim-Gyllensköld adopt as the positive coordinate directions north, west, nadir; that Maxwell, Mascart and Joubert, and Schuster adopt north, west, zenith; and that Schmidt and Von Bezold adopt north, east, nadir. There are thus three groups of papers in this respect.

In meteorological literature Ferrel adopted the Laplacian coordinates, x on axis of rotation, y in the meridian of reference, and z at right angles to the plane $x\,y$ in east longitude. Oberbeck and Margules permute the axes, making z the axis of the earth's rotation. In polar coordinates, with origin at the center of the earth, all use Laplace's system, except Guldberg and Mohn, who count angular distance along the meridian from the equator, instead of from the pole. The system with north polar distance is clearly superior for general investigations. When transference is made of the origin from the center to the surface of the earth, the advantage of Laplace's polar system appears more strongly than ever. The confusion of coordinate axes between the author's is considerable. Ferrel consistently uses the system south, east, zenith, but his notation is irregular and he uses letters, u, v, w, set apart as velocities, for linear distances. Margules adopts the same system of rotation, and Sprung, also, in portions of his treatise on Meteorology. Guldberg and Mohn, Oberbeck (in part), and Sprung (in part) adopt, on the contrary, the opposite surface rotation, east, south, zenith; so, also, Hemholtz, p. 82.

In more distinctly physical treatises, Thompson and Tait, Heaviside, Watson and Burbury, Basset, Boltzmann, Poincaré, and others adopt the convention of right-handed rotation about an axis drawn outward normal to the surface; while Helmholtz and Hertz adopt a left-hand rotation about an outward drawn normal.

It will probably be admitted that modern physics has quite uniformly settled upon three fundamental conventions:

1. Definition of potential, $V = +\frac{m}{r}$.
2. Positive normal drawn outward from the surface.
3. Right-handed rotation, with translation along the positive direction.

It is held by the writer that terrestrial magnetism and meteorology must conform themselves eventually to these three conventions. Any other system will be powerless to resist the influence of the canons of physics, if it is not in harmony with them.

The accompanying Table 1 shows that Maxwell, Mascart and Joubert, and Schuster in terrestrial magnetism; Ferrel, Oberbeck (in part), Margules, and Sprung (in part) already conform to this standard. Gauss, Erman and Petersen, Carlheim-Gyllensköld should change the definition of potential from $V = -\Sigma\frac{m}{r}$ to $V = +\Sigma\frac{m}{r}$, and also the vertical direction from nadir to the zenith. Schmidt and Von Bezold have the right-handed rotation, but the positive normal is drawn inward, and this should be changed to outward; also Von Bezold should change the sign of the potential.

While there are some variations in the literature of meteorology, Ferrel's system, which was fortunately perfect in this respect, has happily helped to put most of the analytical papers on the motions of the atmosphere in an acceptable form. Developing the angle θ from the north pole, and the angle λ toward the east, with radius extended to the zenith, the system x south, y east, z zenith, with u, v, w for velocity, and $\frac{du}{dt}$, $\frac{dv}{dt}$, $\frac{dw}{dt}$ for acceleration, gives a notation which, if used by all writers, would reduce the labor of the comparative study of the laws of the dynamics of the atmosphere to a minimum.

In terrestrial magnetism, unfortunately, the positive magnetic pole of the earth is in the southern geographical hemisphere, and the positive force develops northward, so that x north, y west, z zenith, would be the corresponding system. Confusion was originally introduced by taking the dip in the northern magnetic hemisphere as positive; it is properly negative in pure physics. The simplest change is, therefore, to make the vertical force positive in the Southern Hemisphere, directed upward, and negative in the Northern Hemisphere, with the corresponding values for the dip.

The International Conference at Paris, September, 1896, voted to adopt the following coordinate system in terrestrial magnetism:

TABLE 2.—*The coordinate systems used in meteorological papers.*

Authorities quoted.	Origin at center.						Origin on surface.					
	Rectangular.			Polar.			Rectangular.			Polar.		
	Axis of rotation.	Meridian of reference.	Perpendicular to plane.	Radius.	North polar distance.	East longitude.	South.	East.	Zenith.	Distance from center.	Angle from center.	Around center.
Laplace, Mec. Celeste, I, VIII, § 29, § 35	x	y	z	r	θ	$\tilde{\omega}$	......	......	......	......	......	......
Ferrel, Prof. Paper, S. S., VIII, p. 6	x	y	z	r	θ	ϕ	......	......	N	s	ρ	μ
Ferrel, Meteorol. Research., pp. 370-378	x	y	z	r	θ	ϕ	u	v	h	u	ρ	μ
Ferrel, Report, 1885, C. S. O., pp. 181, 292	x	y	z	r	θ	ϕ	U	V	X	......	......	......
Guldberg and Mohn, Mouv. de l'Atmos., II, p. 4	......	......	......	R	$(90-\theta)$	......	$-x$	y	z	r	......	ϕ
Oberbeck (Abbe's Trans.), pp. 153, 178, 183	z	x	y	r	θ	ϕ	y	x	z	......	......	......
Margules (Abbe's Trans.), p. 300	z	x	y	r	$\tilde{\omega}$	λ	x	y	z	......	......	......

X positive north,
Y positive east,
Z positive vertical,

the latter ordinate, whether positive to the zenith or to the nadir, apparently being undefined in the preliminary report. This decision seems to be of doubtful validity, (1) since in case the vertical direction is positive to the nadir the second convention is disregarded, and (2) if positive toward the zenith, then the third convention is not observed.

There are other reasons for adhering to a system of coordinates embracing the three conventions above recommended, as (1) the usual scheme of trigonometric instruction, (2) the agreement with the cyclonic circulation, when taken positive and right handed in the Northern Hemisphere, (3) the convenience of recording movements of clouds as vectors which are tangent to the stream lines, "as the arrow flies," instead of in the improper, even if popular, notation of the direction from which the wind blows.

Although the meteorological system develops naturally, and by general usage, from the north pole, but the magnetic system from the south pole of the earth, yet some authors may prefer to count from the south point in both systems; in this case the potential and the coordinate forces in terrestrial magnetism will be:

$$V = + \Sigma \frac{m}{r}$$

$$X = -\frac{dV}{dx} = -\frac{dV}{r d\theta}, \text{ positive south.}$$

$$Y = -\frac{dV}{dy} = -\frac{dV}{r \sin\theta \, d\lambda}, \text{ positive east.}$$

$$Z = -\frac{dV}{dz} = -\frac{dV}{dr}, \text{ positive upward.}$$

It is contended in this paper that all discussions and records of observations should conform to the three standard conventions. If terrestrial magnetism can not be brought into full harmony with the accepted meteorological system, then, at least, the only difference allowable should be that the magnetic rotation starts with zero at the north point and increases westward, while the meteorological zero is at the south point and the rotation is positive eastward; in both systems the positive rotation is in the direction north, west, south, east.

AURORA AUSTRALIS OF APRIL 20.

By M. W. CAMPBELL-HEPWORTH, F. R. A. S., Lieutenant Royal Naval Reserves.

The Chief of the Weather Bureau is indebted to Commander J. E. Craig, United States Navy, Hydrographer, in charge of United States Hydrographic Office, for the following copy of a description of an aurora australis observed on board the Canadian Australian Royal Mail Steamship Company's steamer *Aorangi:*

On April 20, in latitude 47° 30′ S., longitude 96° 15′ E., at 6:30 p. m., a diffused light, bearing resemblance to that which may be observed at night over a city strongly lighted by electricity, was observed over the southern arc of the horizon. Horizontal flashes soon spread and flared in every direction from this light above the horizon, increasing in length and brilliancy until at 7:30 p. m. they were shooting across the sky to within 30° of the northern arc of the horizon.

Cones and circles of light traveled rapidly over the whole sky, flashing beams of intense brilliancy from one to the other. This continued until 8:30 p. m. A remarkable change then took place; the sky being cloudless, moon and stars shining brightly, an arch of bright green light fading off into yellow formed over the southern horizon, rose rapidly to a higher and yet higher altitude and was followed by similar arches in regular sequence until there were six distinct arches, their apices being from 10° above the southern horizon to 60° above the northern horizon. These were formed of narrow vertical bands of light from 5° to 20° deep, bright green, and yellow at the upper edges and of a rosy hue at their bases. Subsequently, these arches rapidly changed their shapes in all parts of the sky, others forming, but some kind of luminous curve was always preserved, except in one or two cases, when perfect right angles were formed. At 9 o'clock a brilliant circle formed around the zenith, composed of narrow bundles of light, similar to those already described, but pendent overhead, and having a rotary motion; this circular motion having been apparent in all the formations hitherto mentioned. The circle was about 30° in diameter and the rays of colored light or narrow bands of colored light, as I have elsewhere termed them, were not quite vertical but slightly inclined, thus producing an effect which gave the impression of what one might suppose would occur in the vortex of an electrical cyclone. A cloudless sky showed through the center of this ring-shaped tassel of colored light. It then traveled to the westward. Later, a spiral cord of light formed, having its center at the zenith, exhibiting three distinct turns of a coil. Two intensely bright formations, resembling waterspouts brilliantly illuminated, flared in the west, and a remarkably bright meteor, starting from Canis Major, traveled slowly across the sky, discharging at intervals fragments of color, and thus adding to the splendor of the scene.

Prior to 8:30 p. m., all flashes of light had been horizontal. After that time, they were all vertical. A special feature in this display should be mentioned; these formations had all a westward movement.

After 9:15 p. m., the aurora was less brilliant, but burst into greater activity a few moments afterwards, more especially in the northern semicircle. This display lasted until 9:45 p. m. Atmospheric pressure for the past forty-eight hours had been abnormally low, the barometer remaining below 29.00 inches. At the time of the display it stood at 28.80 inches by "B. T." barometer 244, and was slowly rising. The temperature of the air was 43° F.; the wet bulb reading was 41° F. The wind was west-northwest (true), force from 5 to 4. It had been northwest throughout the day, force 7, and on the day previous, northwest, force from 6 to 8. Squally weather, accompanied by rain, hail, thunder, and lightning, has been experienced from the 18th until noon of the 20th.

On the night of April 22–23, in latitude 45° S., longitude 118° W. to 120° E., from 7 p. m. to 4 a. m., another auroral display was observed exhibiting the phenomena of the arches. At 9 p. m. (about), two arches, one after the other, rose slowly above the horizon, but on this occasion the sky became frequently clouded and the spectacle, although magnificent, had not that awe-inspiring grandeur which startled the eyes of the observer on the night of the 20th.

WIND-BAROMETER TABLE.

By E. B. GARRIOTT, Professor, Weather Bureau.

The following table presents, in form for ready reference, atmospheric signs which have been found to presage certain weather changes and conditions over the middle and upper Mississippi and lower Missouri valleys, the Great Lakes, the Ohio Valley, and the Middle Atlantic and New England States:

Barometer (reduced to sea level).	Wind direction.	Character of weather indicated.
30.00 to 30.20, and steady	westerly	Fair, with slight changes in temperature, for one to two days.
30.00 to 30.20, and rising rapidly	westerly	Fair, followed within two days by warmer and rain.
30.00 to 30.20, and falling rapidly	s. to e.	Warmer, and rain within 24 hours.
30.20, or above, and falling rapidly	s. to e.	Warmer, and rain within 36 hours.
30.20, or above, and falling rapidly	w. to n.	Cold and clear, quickly followed by warmer and rain.
30.20, or above, and steady	variable	No early change.
30.00, or below, and falling slowly	s. to e.	Rain within 18 hours that will continue a day or two.
30.00, or below, and falling rapidly	se. to ne.	Rain, with high wind, followed within two days by clearing, colder.
30.00, or below, and rising	s. to w.	Clearing and colder within 12 hours.
29.80, or below, and falling rapidly	se. to ne.	Severe storm of wind and rain imminent. In winter, snow and cold wave within 24 hours.
29.80, or below, and falling rapidly	e. to n.	Severe northeast gales and heavy rain or snow, followed, in winter, by cold wave.
29.80, or below, and rising rapidly	Going to w.	Clearing and colder.

The character of the precipitation, whether rain or snow, is governed by the temperature.

Weather wisdom, gained by an observance of local atmospheric signs and conditions, has been possessed by man from time immemorial. Much of this wisdom has been embodied in proverbs which possess considerable merit for the sections and localities in which they originated. In farming communities sayings regarding the wind, the temperature, the clouds, and evidences of atmospheric moisture have been handed down from generation to generation; and in mari-